VOLUME 7

FINAL REPORT

FLEET RELIABILITY ASSESSMENT PROGRAM

APPENDICES

NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA

Published by direction of Commander, Naval Electronics Systems Command.

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1 SEPTEMBER 1977

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Total number of pages in this manual is 57 consisting of the following.

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Title	0
A	0
i to iv	0
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Zero in this column indicates an original page.

FLEET RELIABILITY ASSESSMENT PROGRAM

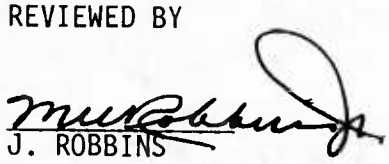
DEPARTMENT OF THE NAVY

NAVAL ELECTRONIC SYSTEMS COMMAND

PREPARED UNDER THE DIRECTION OF

W. WALLACE
RELIABILITY ENGINEERING BRANCH

REVIEWED BY



J. ROBBINS
SYSTEMS EFFECTIVENESS DIVISION

APPROVED BY

G. FRIESE, CAPTAIN, USN
DEP CDR LOGISTICS DIRECTORATE

RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY

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APPENDIX A

FRAP TEAM MEMBERS

Name	NAVWPNSUPPCEN Crane	NOSC San Diego	NESTED Pax River	NESEC Vallejo
Bob Marks	X			
Charles Hamstra	X			
Charles Welp	X			
David Hoffman	X			
Dennis Lyons			X	
Dennis Maher			X	
Dick Kent	X			
Ed Glunt		X		
George Allen	X			
Jack Ekwall	X			
Jack MacDonald				X
Jim Clemons	X			
John Chow				X
Joseph Bracewell			X	
Kenn Smith	X			
Kris Keperling			X	
Marty Leopold			X	
Max Garwood	X			
Robert Saum	X			
Robert Whaling		X		

APPENDIX B
FRAP EQUIPMENT SAMPLE SIZES

	EQUIPMENT						
TYPE OF PLATFORM	AN/ URC-85	AN/ WSC-3	AN/ SSR-1	AN/ UYK-20	AN/ WRR-7	AN/ ART-50	AN/ ARR-7
AS	NR	NR	NR	NR	2-LANT 2-PAC 5-Fleet*	NR	NR
CG	NR	NR	3-LANT 3-PAC 14-Fleet*	NR	NR	NR	NR
CV, CVA, & CVN	2-LANT 2-PAC 7-Fleet*	NR NR	2-LANT 2-PAC 7-Fleet*	NR	NR	NR	NR
DD	NR	3-LANT 2-PAC 0-Fleet*	NR	3-LANT 2-PAC 0-Fleet*	NR	NR	NR
DDG	2-LANT 0-PAC 2-Fleet*	2-LANT 4-PAC 0-Fleet*	NR	2-LANT 4-PAC 0-Fleet*	NR	NR	NR
FF	NR	1-LANT 4-PAC 0-Fleet*	3-LANT 3-PAC 32-Fleet*	1-LANT 4-PAC 0-Fleet*	NR	NR	NR
SSBN	NR	NR	NR	NR	4-LANT 4-PAC 41-Fleet*	NR	NR
SSN	NR	9-LANT 6-PAC 0-Fleet*	NR	9-LANT 6-PAC 0-Fleet*	NR	NR	NR
TACAMO AIRCRAFT	NR	NR	NR	NR	NR	4-VQ3 4-VQ4 18-Fleet*	4-VQ3 4-VQ4 0-Fleet
TOTAL FLEET INSTALLA-TIONS	11	0	202	0	46	18	0

*INDICATES NUMBER IN FLEET INSTALLED IN THAT SPECIFIC CLASS OF SHIPS

NR - None Required

HULL NO.'S FOR FRAP SAMPLES

TYPE OF PLATFORM	AN/ URC-85	AN/ WSC-3	AN/ SSR-1	AN/ UYK-20	AN/ WRR-7	AN/ ART-50	AN/ ARR-77
AS	NR	NR	NR	NR	19 32 31 33	NR	NR
CG	NR	NR	CG 4 27 21 28 23 30	NR	NR	NR	NR
CV, CVA, CVAN	CV 60 62 61 CVAN 65	NR	CV 60 62 61 CVAN 65	NR	NR	NR	NR
DD	NR	DD 937 948 938 950 941	NR	DD 937 948 938 950 941	NR	NR	NR
DDG	DDG 39 42	DDG 2 16 13 17 14 24	NR	DDG 2 16 13 17 14 24	NR	NR	NR
FF	NR	FF 1038 1066 1048 1067 1064	FF 1044 1069 1045 1089 1055 1097	FF 1038 1066 1048 1067 1064	NR	NR	NR
SSBN	NR	NR	NR	NR	SSBN 599 627 600 634 601 642 608 655	NR	NR
SSN	NR	SSN 588 666 594 668 595 669 596 670 646 671 652 673 662 674 675	NR	SSN 588 666 594 668 595 669 596 670 646 671 652 673 662 674 675	NR	NR	NR
TACAMO AIRCRAFT	NR	NR	NR	NR	NR	NOT YET KNOWN	NOT YET KNOWN
TOTAL FLEET INSTALLA-TIONS	11	0	202	0	46	18	0

APPENDIX C

C. COMPUTER PROGRAM SUMMARY AND DATA CODING

C-1 INPUT DATA. The data used in the program consists of information obtained from the OPNAV 4790 Maintenance Action Forms (MAFs) and during visits (initialization, some censored, and termination readings) to platforms whose equipment was in the FRAP sample. After technical editing, the data are transcribed from the MAFs onto three 80 column card facsimiles as described in Attachment A, Instructions for Coding Information from OPNAV 4790/2K Forms for Submission for Electronic Data Processing and then punched into IBM cards.

C-2 OUTPUT DATA. When more than four distinct readings were obtained, graphs are obtained showing the fit of the best theoretical probability distribution to the nonparametric functions for time-to-failure (TTF), repair time (RT) and down time (DT) for each system and WRA. Graphs are presented for other probability distributions tried (exponential and Weibull used for TTF and log-normal, exponential, and Weibull used for RT and DT). These graphs also present the estimated mean and medium using the assumed theoretical probability distribution.

After the graphs, a listing is given of the basic information pertaining to each FRAP action of each platform. Below these data, the duty cycles (on TTF listing only), results of Lilliefor's Kolmogorov-Smirnov (K-S) goodness-of-fit test, estimated mean and medium, 90% lower and upper confidence limits, and comparison with specified values are given.

Following the above, TTF and RT information is presented for each O-level involved in a system failure. This information includes the O-level nomenclature and reliability block diagram identification, number of observations, range of observed times, estimated mean, and 90% upper and lower confidence limits (the exponential distribution was assumed for the O-level TTF calculations and the log-normal for the O-level RT calculations). Specified values (MIL-HDB-217 predictions for TTF) are given and compared to the confidence limits after which a statement is made whether a reliability or maintainability problem exist.

For these components for which a reliability or maintainability problem is indicated by the confidence limits, a summary of 2K forms pertaining to those failures are given. The 2K forms are identified by their JCN's.

Finally, the systems inherent availability (average time system available assuming only system down time is repair time) is presented. Then, the mean, medium and confidence limits are presented for system observed availability (ratio of TTF to sum of TTF and DT for each maintenance action). These are obtained using computer simulation methods.

INSTRUCTIONS FOR CODING INFORMATION FROM
OPNAV 4790/2K FORMS FOR SUBMISSION FOR
ELECTRONIC DATA PROCESSING

I. CARD NO. 1

Column No's	Code	Description
1		Type of Maintenance Action Report
	Ø	Initial Reading
	1	Deferred (equipment down or in limited use status) but not completed
	2	Deferred (equipment down or in limited use status) and completed
	3	Completed without deferral
	4	Final Report
	5	Restart (change in equipment serial no's)
	6	Deferred (equipment in full use status but spare parts deferred) but not completed
	7	Deferred (equipment in full use status but spare parts deferred) and completed
	8	Censored readings
2-14		Job Control Number (JCN) with columns 2-6 being the platforms unit identification code (UIC), columns 7-10 the work center of the platform, and columns 11-14 being the job sequence number
15-30		Equipment nomenclature,e.g. AN/WSC-3, AN/SSR-1, etc.
31		When discovered code (need for Maintenance) per regular 3-M (should be on 2K but if not, complete using available information if possible)
	1	Lighting off or starting
	2	Normal operation
	3	During operability tests
	4	During inspection
	5	Shifting operational modes
	6	During PMS
	7	Securing
	Ø	Not applicable (used when reporting a configuration change, printing services, etc.)
32		Status of Equipment (when need for Maintenance discovered) per regular 3-M (Should be on 2K but If not complete using available information if possible)
	1	Operational
	2	Non-operational
	3	Reduced capability
	Ø	Not applicable

Column No's	Code	Description
33		Cause of Failure or malfunction per maintenance man's opinions when need for Maintenance First discovered per regular 3-M
	1	Abnormal environment
	2	Manufacturer/installation defects
	3	Lack of knowledge or skill
	4	Communication problems
	5	Inadequate instructions/procedure
	6	Inadequate design
	7	Normal wear and tear
	Ø	Not applicable(no malfunction)or other
34		Deferral Reason - Why maintenance action cannot be done at time of deferral per regular 3-M
	1	Ships force work backlog/operational priority
	2	Lack of material
	3	No formal training in equipment
	4	Formal training inadequate in this equipment
	5	Inadequate school practical training
	6	Lack of facilities/capabilities
	7	Not authorized for ships force accomplishment
	8	For ships force overhaul and availability work list
	9	Lack of technical documentation
	Ø	Other or not applicable, if other describe in "remarks"
35-47		Identification or serial numbers of equipment or systems on which maintenance action is being performed
48-74		Location per regular 3-M. Should consist of four elements separated by dashes. The first element is Compartment No. or Deck description, the second element is the deck level, the third element the frame, and the fourth element the side of the ship
75-78		When discovered date - Per regular 3-M. Julian date when equipment failure or malfunction discovered.
79		FREE column (Number of Equipments)
80	1	Card Number

II CARD No. 2

Columns No's	Code	Description
1-4		Total Ships Force manhours expended prior to deferral (to the nearest hour) per regular 3-M
5-8		Julian deferral date per regular 3-M
9-12		Total ships force manhours estimated to complete deferred maintenance per regular 3-M (to the nearest hour) If auto used is less than 3 hours
13-16		Deadline date per regular 3-M. The latest possible date outside assistance and ships force work must be completed
17-18		Action taken (should be on 2K but if not complete using available information if possible)
	1	Maintenance action completed, parts drawn from supply
	2	Maintenance action completed, required parts not drawn from supply (local manufacture preexpended bins, etc.)
	3	Maintenance action completed, no parts required
	4	Cancelled
	5	Configuration Change (When this code is used, one of the following suffix codes best describing the configuration change is also to be used

A - Partially completed alterations/field change
B - Fully completed alteration/field change
C - Equivalent alteration completed
D - Alteration/field change directive cited is not applicable
E - Exchange (removed one equipment and installed another)
F - Removed equipment (no exchange)
G - Installed equipment (no exchange)

Columns No's	Code	Description
	Ø	None of the above. Described in remarks/ description section
19-22		Ships Force Manhours (to the nearest whole hour). Total manhours expended during maintenance or for deferrals total manhours expended after submission per regular 3-M
23-26		Julian date of maintenance action completion per regular 3-M
27-29		Active Maintenance Time per regular 3-M. The total clock hours, to the nearest whole hour, during which ships force maintenance was actually performed (or the time to repair)
30		Trouble Isolation per regular 3-M. A single numeral to indicate to the nearest 10%, the percentage of active maintenance time expended in trouble shooting.
31-35		The 3-M regular ETM reading given in Block 34 of the 2K form. (To the nearest tenth of an hour)
36		Fleet Designation
	1	Atlantic Fleet
	2	Pacific Fleet
37		TYCOM Designation
	1	AIR
	2	SUB
	3	Surface
38-39		Platform type designation
	Ø1	Aircraft
	Ø2	Aircraft Carriers (CV, CVN, CVA's etc.)
	Ø3	SSBN
	Ø4	SSN
	Ø5	CG
	Ø6	DD
	Ø7	DDG
	Ø8	FF
	Ø9	AS
	1Ø	AOR
	11	LSD
	12	FFG
	13	LST
	14	LPH
	15	LCC
	16	LPD

Columns No's	Code	Description
40-44		The ETM reading at time of discovery of failure or malfunction desired by FRAP (to the nearest tenth of an hour). (If not given enter the regular 3-M ETM reading columns 31-35, card No. 2. If these not given use the ETM readings at completion or deferral given in Columns 75-79, Card No. 2)
45-48		ETM Key Item Serial Number at time of Discovery of failure or malfunction. The serial number enabling a change in ETM's to become evident. Use all four places. If any missing add 0 between given letters and number, e.g. B 11 record as B Ø11.
49-50		Temperature in ^{o}C when failure or malfunction discovered
51		Vibration when failure or malfunction discovered
	Ø	None
	1	Slight
	2	Normal
	3	Higher than normal
	4	Extremely high
52		Relative humidity to nearest 10% (indicated by a single numeral) at times of discovery of failure or malfunction.
53-72		Additional ETM Readings for the AN/URC-85 for when failure or malfunction discovered. (In the case of the URC-85, the ETM readings already described above are for the Rec Ch 2 Mode of the URC-85). The additional readings are entered as follows:
53-57		Receive CH 1 Mode
58-62		Transmit CH 2 mode
63-67		Transmit CH 1 Mode
68-72		Transmit 1KW Mode
73		Free Column
74		Equipment Code
	0	AN/URC-85 X-1KW
	1	AN/SSR-1
	2	AN/WSC-3
	3	AN/UYK-20
	4	AN/WRR-7
	5	AN/ART-50
	6	AN/URC-85 X-CH1
	7	AN/URC-85 X-CH2
	8	AN/URC-85 R-CH1
	9	AN/URC-85 R-CH2

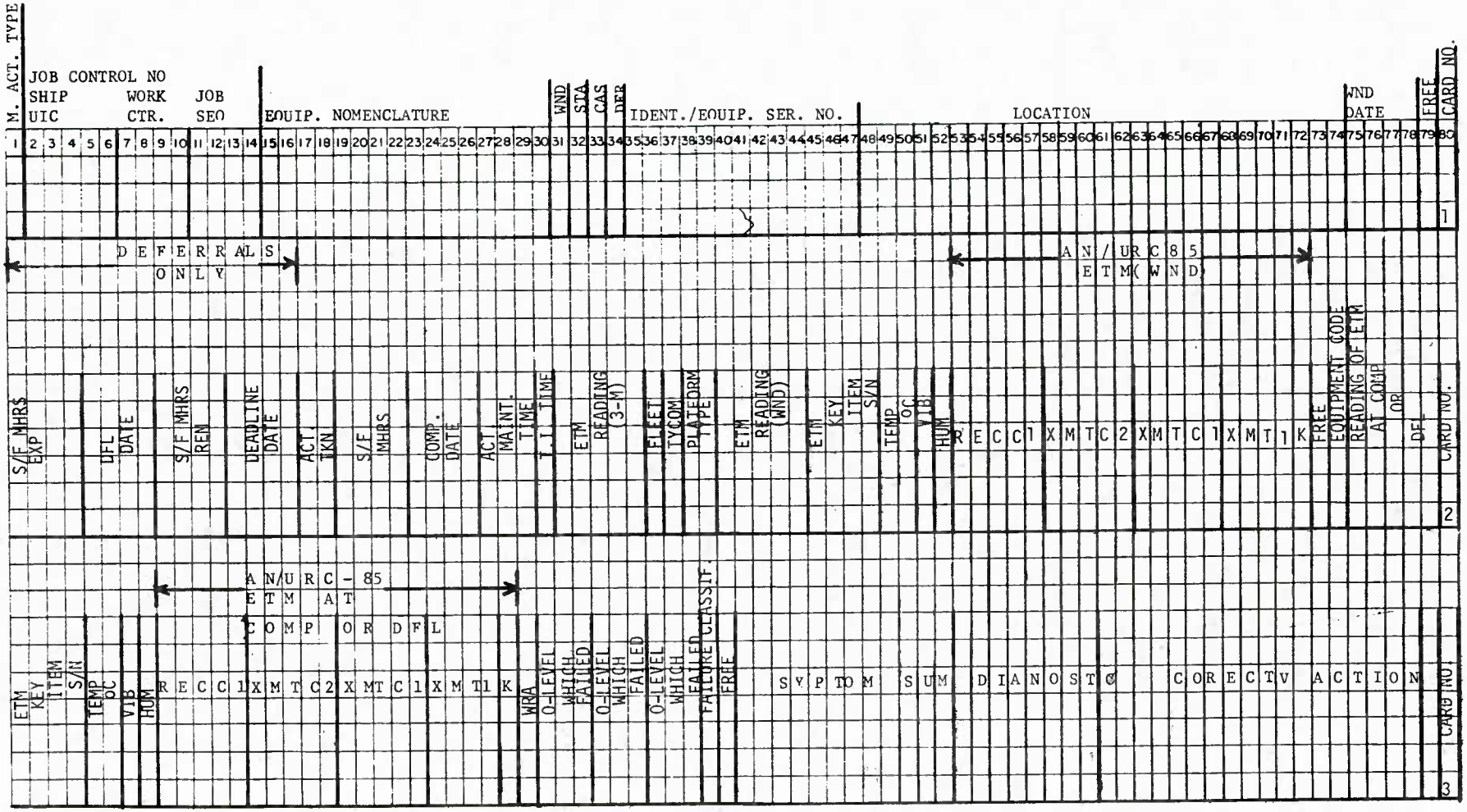
Columns No's	Code	Description
75-79		The ETM Reading at time of completion or deferral of maintenance action desired by FRAP (to the nearest tenth of an hour) (If not given, enter the regular 3-M ETM reading of columns 31-35, Card No 2. If this is not given, enter the FRAP desired ETM reading for time of discovery of failure or malfunction given in columns 40-44, Card No 2.)
80	Ø2	Card No. 2

III CARD NO. 3

Column No's	Code	Description
1-4		ETM Key Item Serial Number at time of completion or deferral of maintenance action. The serial number enabling a change in ETM's to become evident. Use all four places - if any missing add 0 between letters and number, or B11 record as B011.
5-6		Temperature in oC when maintenance action completed or deferred.
7		Vibration when maintenance action completed or deferred.
	Ø	None
	1	Slight
	2	Normal
	3	Higher than normal
	4	Extremely high
8		Relative humidity to the nearest 10% (indicated by a single numeral) at time maintenance action completed or deferred.
9-27		Additional ETM Readings for the AN/URC-85 when maintenance actions completed or deferred. (For the URC-85, the reading in columns 75-79 is for the Receive channel 2 Mode). Additional readings are entered as follows:
9-13		Receive Channel 1 Mode
14-18		Transmit Channel 2 Mode
19-23		Transmit Channel 1 Mode
24-28		Transmit 1KW Mode
29		WRA No. from Reliability Block Diagram
30-39		O-Level No. which failed. Designated with Reliability Block Diagrams appropriate numeric code. Always use three numbers, i.e. 001 for 1, 010 for 10, 100 for 100 etc
30-32		Use these columns for the Major O-Level Failing
33-35		Use these columns for the O-Level Failure of the next importance
36-38		Use these columns for the O-Level Failure of the next importance.

Column No's	Code	Description
39		Equipment Failure Classification
	Ø	Revelant or nonrevelant
	1	Revelant
	2	Non-revelent
40		FREE
41-52		Failure Sympton Summary - Use recognizable abbreviations to maximum extent possible - For example, BUFF = Buffering, PWR = Power, LIHT = Light, COMMUN = Communication, TRANSLAT = Translation
53-60		Diagnostic Summary. Again use recognizable and constant abbreviations to the maximum extent possible. For example, SW = Switch, OBS = Observed, TECH = Technical, REP = Representative
61-78		Corrective Action Taken. Again use recognizable abbreviation to the maximum extent possible. For example, REPL = Replaced, ADJ = Adjusted, CONK = Connect, INSTR = Instruction, CLAFY = Clarify.
79		FREE
80	3	Card No.

FOR FRAP


M. ACT. TYPE
JOB CONTROL NO
SHIP
UIC
WORK CTR.
JOB SEQ
EQUIP. NOMENCLATURE
WND
STA
CAS
DER
IDENT./EQUIP. SER. NO.
LOCATION
WND DATE
FREE
CARD NO.
1
DEFERALS ONLY
AN/URC85 ETM(WND)
S/E MHRS EXP
UFL DATE
S/E MHRS REN
DEADLINE DATE
ACT TKN
S/E MHRS
COMP. DATE
ACT MAINT. TIME
T.T. TIME
ETM READING (3-M)
FLEET
TYCOM
PLATFORM TYPE
ETM READING (WND)
ETM KEY ITEM S/N
TEMP OC
VIB
HUM
RECC1 XMTC2 XMTC1 XMT1K
FREE
EQUIPMENT CODE
READING OF ETM AT COMP OR DFL
2
AN/URC-85 ETM AT COMP OR DFL
ETM KEY ITEM S/N
TEMP OC
VIB
HUM
RECC1 XMTC2 XMTC1 XMT1K
WRA
O-LEVEL WHICH FAILED
O-LEVEL WHICH FAILED
O-LEVEL WHICH FAILED
FAILURE CLASSIF.
FREE
SVPTOM SUM DIAGNOSTIC
CORRECTIVE ACTION
CARD NO.
3

APPENDIX D

D. AUTOMATED DATA ANALYSES

D-1.1 RELIABILITY. The automated reliability data analyses output includes graphs, input assessment data, an O-Level summary, and a summary of pertinent maintenance action forms as described below.

D-1.2 GRAPHS. For each system and each WRA of an system with four or more failures, one or two graph(s) of system operating time versus probability of failure is (are) presented.

D-1.3 On each graph a non-parametric step function is presented. This function is obtained by arranging failure time, t_i's, and censored times in ascending order and calculating probability of failure at or before t_i, $F(t_i)$, as follows:

$$F(t_i) = 1 - \prod_{i=1}^{k} [(N_i + 1 - r_i)/(N_i + 1)] \qquad (1)$$

where N_i is the number of failures at t_i plus the number of failures and censored times following t_i, r_i is the number of failures at t_i, and k is the last failure time, t_k.

D-1.4 A graph is given showing the fit of the exponential function to non-parametric step function. The expected time to failure known as the Mean Time Between Failure (MTBF), the total equipment operating time divided by the total number of failures, is presented on this graph. Additionally, the median of the exponential, the MTBF times ln 2 is given. The exponential is obtained as follows:

$$F(t_i) = 1 - EXP(-t_i/MTBF) \qquad (2)$$

D-1.5 If Lilliefor's Kolmogorov-Smirnov (K-S) test shows the exponential cannot be assumed, the two-parameter Weibull

$$F(t_i) = 1 - EXP(-\alpha t_i^{\beta}) \qquad (3)$$

is fitted to the non-parametric step function and graphed. The α and β parameters are obtained using the following non-parametric reliabilities.

$$R(t_i) = \prod_{i=1}^{k} [(N_i + 1 - r_i)/(N_i + 1)] \qquad (4)$$

and the following transformation

$$R(t_i) = EXP(-\alpha t_i^{\beta})$$

$$\ln \ln [1/R(t_i)] = \ln \alpha + \beta \ln t_i \qquad (5)$$

through taking ln's twice. The latter equation is in the form of a straight line

$$Y = a + bX \qquad (6)$$

Thus, a = $\ln\alpha$ and b = β are obtained through the method of least squares with the following formulae:

$$a = [\Sigma Y_i - b\Sigma X_i]/n = \bar{y} - b\bar{x} \qquad (7)$$

$$b = [n\Sigma X_i Y_i - \Sigma X_i \Sigma Y_i]/[n\Sigma X_i^2 - (\Sigma X_i)^2] \qquad (8)$$

with n = k, $x_i = t_i$ and $y_i = \ln \ln (1/R(t_i))$. If β is less than one a decreasing failure rate is indicated and if β greater than one an increasing failure rate is indicated. The expected time to failure, indicated on the graph as MTBF, when the Weibull is used is obtained as follows:

$$\mu = \alpha^{-1/\beta}\, \Gamma(1 + 1/\beta) \qquad (9)$$

The median based on the calculated Weibull is also given. The median is obtained through the simulation method discussed below under availability.

D-1.6 If there is less than 4 failures, the exponential is assumed and graphs are not presented.

D-1.7 Fleet Reliability Assessment Data. After the graphs, a listing is given of basic information pertaining to each FRAP action of each reporting platform. The information presented is as follows:

(1) Maintenance Action TYP-MTYP-First Column. Basically, there are five types of action under FRAP. These are initialization indicated by a 0; completed maintenance action without deferral indicated by a 3; deferred maintenance action indicated by either a 1, 2, 6, or 7; censored (no failure) readings indicated by an 8, and termination reading indicated by a 4. For the deferred maintenance actions, a 1 indicates system was down or in limited use status with maintenance action deferred, a 2 indicates completion of this maintenance action, a 6 indicates system was in full use status but spare parts deferred with maintenance action not completed on spare parts, and a 7 indicates the completion of this maintenance action. (When systems were changed on a platform a reinitialization was generally required).

(2) Date. The first column gives the Julian dates of initialization, censored, and termination and date need for maintenance action discovered. The second column gives the Julian date maintenance action completed and repeats the dates of censored and termination readings.

(3) WRA and O-Level Failing. These columns give the WRA number and O-Level Number from the Reliability Block Diagram for the failing parts. The major O-Level failing is identified in the OL1 column with the other O-Levels failing being given in the OL2 and OL3 columns in order of importance.

(4) ETM Readings. The first column, designated ETM, contains the initialization readings and the regular 3-M readings (Block 34 of OPNAV 4790/2K form) for maintenance actions when given. The second column, designated ETM 1 contains the reading when need for maintenance action was discovered, the readings for censored observations, and termination readings. The third column, designated ETM 2 contains the readings for when maintenance action was completed and a repeat of the censored and termination readings.

(5) Operating Time. The column titled operate contains the cumulative operating time excluding repair time since initialization for each system at time of failure or censored reading.

(6) Duty Cycle. The column designated duty contains the cumulative duty cycle since initialization at time maintenance action is completed or censored reading is

taken. Duty cycle is defined as the operating time divided by calendar time which is: (Date of ETM reading - Date of Initialization) X (24 hours).

(7) Time to Failure (TTF). This column contains the operating time of the system between initialization and the first failure, between succeding failures, and between censored readings and the last failure or initialization.

(8) System (SYS). This column identifies the concerned FRAP equipment as follows:

0 - AN/URC-85 X-1KW
1 - AN/SSR-1
2 - AN/WSC-3
3 - AN/UYK-20
4 - AN/WRR-7
5 - AN/ART-50
6 - AN/URC-85 X CH1 (Channel 1 Transmit mode)
7 - AN/URC-85 X CH2 (Channel 2 Transmit mode)
8 - AN/URC-85 R CH1 (Channel 1 Receive mode)
9 - AN/URC-85 R CH2 (Channel 2 Receive mode)

(9) Unit Identification Code (UIC). The first five digits (leading zeros suspressed) present the UIC's of the FRAP reporting platforms. The last digit identifies multiple equipment on the same platforms with a zero indicating there is only one equipment.

D-1.8 System and WRA Distributional Calculations. A page containing the distributional calculations follows the data listing. The tabular listing presents:

(1) The operating times between failures, t_i, and the time between censored readings and last failure or initialization in ascending order in the time to fail column.

(2) The number of failures and censored reading at each time.

(3) The number of observations at and following each t_i in the survivors column, N_i in equations (1) and (4).

(4) The non-parametric F (t_i) using equation (1) in the NPF column.

(5) The exponential F (t_i) using equation (2) in the exponential column.

(6) The maximum of the differences at each t_i between the exponential and the non-parametric step-function at t_i and at t_{i-1}.

D-1.9 Below the tabular presentation the following is given:

(1) The total calendar hours since initialization, and duty cycle, the operating hours divided by calendar hours. These are followed by the number of failures and the observed failure rate, the number of failures divided by total equipment operating hours.

(2) The maximum of the maximum difference column, the critical value for Lilliefor's K-S test for a significance level of .10 and the observed number of failures and a statement giving the appropriateness of the exponential assumption.

(3) If the exponential cannot be assumed, the Weibull parameters calculated as previously described are given next.

(4) After the appropriate distribution has been ascertained, the estimated mean, estimated median, and 90% lower and upper confidence limits, are given. The equipment's specified MTBF is given and compared to the upper confidence limit. If this limit is less than the specified value, a equipment reliability problem is indicated. If the limit is greater than the specific value, the equipment is considered as meeting the specification and this is indicated. The confidence limits are calculated as follows:

(a) Exponential

$$[2T/\chi^2_{.9,2k+2}] \leq MTBF, \theta \leq [2T/\chi^2_{.1,2k}] \quad (10)$$

where T is total operating time, k is the total number of failures, and χ^2 is the value of the Chi-square distribution for the given degrees of freedom, 2 k + 2 and 2k at the indicated percentiles .90 and .10, respectively.

(b) Weibull

The central limit thereon was applied to obtain the confidence intervals for the mean of the Weibull distributions as follows:

$$\hat{\mu} - t_{.1,k-1}\hat{\sigma}/\sqrt{k} \leq \mu \leq \hat{\mu} + t_{.1,k-1}\hat{\sigma}/\sqrt{k} \quad (11)$$

where $\hat{\mu}$ is obtained using equation (9) and the calculated α and β parameters, t is the value of the Student's t- distribution with k-1 degree of freedom at the .10 percentile, k being the total number of failures, and $\hat{\sigma}$ is as follows:

$$\hat{\sigma}^2 = \alpha^{-2/\beta}[\Gamma(1+2/\beta) - (\Gamma(1+1/\beta))^2] \quad (12)$$

D-1.10 O-Level Summary. Following the distributional and related calculations, information is presented for each O-Level failing if the system or WRA does not meet or it is questionable whether they meet specifications. For each O-Level failing the following is presented:

(1) Identification - The WRA and O-Level number on the Reliability Block Diagram followed by formal O-Level nomenclature. A 999 indicates those failures which could not be assigned to an O-Level. Similarly a 9 is used for the WRA when a failure cannot be assigned to a specific WRA.

(2) The mean time between failures and the lower and upper 90% confidence limits obtained using equation (10). (The exponential was assumed here due to the expected low number of failures).

(3) Number of each O-Level failing.

(4) The MTBF obtained using the MIL-HDB-217 predicted failure rates. In case of multiple number of the same O-Level, the failure rates were added and then the reciprocal obtained for the MTBF. These MTBF's are given in the spec MTBF column.

(5) The O-Level component low and high observed time to failure.

(6) Whether a reliability problem exist or not. A reliability problem exists if the upper confidence limit is less than the spec MTBF.

D-1.11 2K FOR PROBLEM AREAS. For those components for which areliability problem is indicated by the confidence limits described in the above sections, a summary of 2K forms pertaining to those failures is given. The 2K forms are identified by their JCN's.

D-1.12 MAINTAINABILITY. The automated maintainability data analyses output includes graphs, input assessment data, distributional calculations, and O-Level summary, and a summary of pertinent maintenance action forms as described below.

D-1.13 GRAPHS. For each system and each WRA of a system with four or more repair times, one to three graphs of repair times versus the probability of repair completion are presented. Repair time is defined as the time required to repair the equipment when parts and capabilities are available on participating platforms. The repair time is obtained from Block 32, Active Maintenance Time, of the OPNAV 4790/2K Form when given. If this is not given but time is given in Block 30, S/F MHRS, of the 2K Form, the latter time is used.

D-1.14 On each graph a non-parametric maintainability step-function is presented. This function is obtained by arranging the repair times, t_i's, in ascending order and calculating the probability of repair within t_i or less time, $M(t_i)$, as follows:

$$M(t_i) = \sum_{j=1}^{i} n_j / N+1 \qquad (13)$$

when n_j is the number of repair times occuring at t_i, $\sum n_j$ the number of repair times occuring at or prior to t_i, and N is the total number of repair times.

D-1.15 A graph is given showing the fit of the log-normal function to non-parametric function. The log-normal function is given by:

$$M(t_i) = \int_0^{z_i} [1/\sigma_z \sqrt{2\pi}]\, EXP[-(z_i - \mu_z)^2/2\sigma_z^2]\, dz \qquad (14)$$

where z_i equals ln t_i and μ_z and σ_z equals the mean and standard deviation, respectively, of the ln's of the t_i's estimated as follows:

$$\hat{\mu}_z = [\Sigma \ln t_i]/N \qquad (15)$$

$$\hat{\sigma}_z^2 = [N \Sigma n_i (\ln t_i)^2 - (\Sigma n_i \ln t_i)^2]/N(N-1) \qquad (16)$$

$$\hat{\sigma}_z = |\sqrt{\hat{\sigma}_z^2}|$$

The average of the observed repair times, MTTR, and the median of these repair times (the anti-log of the mean of the ln t_i's) are given on the graphs.

D-1.16 If Lilliefors Kolmogorov-Smirnov (K-S) test shows the log-normal distribution cannot be assumed, a graph is given showing the fit of the exponential (equation 2) to the non-parametric step function. The expected time to repair known as the Mean Time To Repair (MTTR) is estimated by the average of the observed repair times. Additionally, the median for the exponential is given.

D-1.17 If the Lilliefors K-S test shows the exponential cannot be assumed, the two parameter Weibull

$$M(t_i) = 1 - EXP(-\alpha t_i^{\beta}) \qquad (17)$$

is fitted to the non-parametric step function and graphed. The α and β parameters are obtained using the non-parametric values obtained with equation (13) and ln transformations as follows:

$$1 - M(t_i) = 1 - [1 - EXP(-\alpha t_i^{\beta})] = EXP(-\alpha t_i^{\beta}) \qquad (18)$$

$$\ln \ln \{1/[1-M(t_i)]\} = \ln \alpha + \beta \ln t_i \qquad (19)$$

The latter equation is in the form of a straight line as shown in equation (6). Thus, $a = \ln \alpha$ and $b = \beta$ are obtained using the least squares equations (7) and (8) only in this case $y_i = \ln \ln [1/(1-M(t_i))]$ and t_i is the repair time. If β is less than one, a decreasing repair rate is indicated and if β is greater than one, an increasing repair rate is indicated. The expected time to repair, indicated on the graph as MTTR, when the Weibull is used is obtained using formula (9). The median based on the Weibull is also given on the graph. This is obtained through the simulation method discussed below under availability.

D-1.18 If there is less than four repair times, the log-normal is assumed and graphs are not presented.

D-1.19 Graphs are also obtained for down time in accordance with the above procedures with the exception WRA's are not considered. Down time is defined as time system was down or in limited use status. It is the difference between the Julian date when repair was completed and the Julian Date when need for maintenance action was discovered multiplied by 24 hours if there is over a day difference. If the maintenance action was discovered and completed on the same day, the repair time is used for the down time.

D-1.20 Fleet Maintainability Assessment Data. After the graphs, a listing is given of basic maintainability information for each FRAP action of each reporting platform. The information presented is as follows:

(1) WRA and O-Level Failing. These columns give the WRA number and O-Level number from the Reliability Block Diagram for the failing parts as discussed in paragraph 3-6.7(3).

(2) Discovery Date. This column gives the Julian date the need for maintenance action was discovered.

(3) Completion Date. This column gives the Julian date the maintenance action was completed.

(4) Down Time. As indicated this column gives the down time of equipment in hours.

(5) Repair Time. This column includes repair times.

(6) System (SYS). This column identifies the applicable FRAP equipment as given in paragraph 3-6.7(8).

(7) Unit Identification Code (UIC). This column identifies the FRAP reporting platform as described in paragraph 3-6.7(9).

D-1.21 Systems and WRA Distributional Calculations. Distributional calculations are presented after the data listing. The tabular listing presents:

(1) The repair or down time, t_i.

(2) The number of maintenance actions with the given repair or down time.

(3) The cumulative number of maintenance actions requiring t_i or less repair or down time.

(4) The non-parametric, $M(t_i)$, using equation (13) in the NPF column.

(5) The log-normal $M(t_i)$ using equation (14) in the log-normal column. If the log-normal is not accepted, the above columns are repeated in a following table with the exponential, $M(t_i)$ of equation (17) given in a exponential column.

(6) The maximum of the difference at each t_i between the log-normal or the exponential and the non-parametric step-function at t_i and at t_{i-i}.

D-1.22 Below the tabular presentation, the following is given:

(1) The total of the repair or down times, the number or repairs or down times, and the observed repair or down time rate.

(2) The mean (x-bar) and standard deviation (std dev) of the ln's of repair or down times in the case of the log-normal distribution.

(3) The maximum of the maximum difference column, the critical value for Lilliefors K-S test for a significance level of .10 and the observed number of repair or down times followed by a statement whether or not the log-normal or exponential distribution can be assumed.

(4) If the log-normal or exponential cannot be assumed, Weibull parameters calculated as previously described are given next.

(5) After the appropriate distribution has been ascertained, the estimated mean, the estimated median, and 90% lower and upper confidence limits are given. The specified MTTR is given and compared to the lower confidence limit. If this limit is greater than the specified, a maintainability problem is indicated. If the limit is less than the specified value, the equipment is considered as meeting specifications. (No specified value is given for down time). The confidence limits are calculated as follows:

(a) Log-normal. First, confidence limits are found for the ln's using this equation:

$$\hat{\mu}_z - t_{.1,k-1}\,\hat{\sigma}_z/\sqrt{k} \leq \mu_z \leq \hat{\mu}_z + t_{.1,k-1}\,\hat{\sigma}_z/\sqrt{k} \qquad (20)$$

where $\hat{\mu}_z$ and $\hat{\sigma}_z$ are as defined in equations (15) and (16) and t is the value of Student's t-distribution with n-1 degrees of freedom with k being the total number of repair on down times. To obtain limits in the observed repair and down times units, the anti-ln's of the above values are obtained which gives confidence limits on the median of the repair and down times.

(b) Exponential. The equation used is

$$\left[2T/\chi^2_{.9,2k+2}\right] \leq MTTR \leq \left[2T/\chi^2_{.1,2k}\right] \qquad (21)$$

where T is total repair or down time, k is the total number of observed repair or down times, and χ^2 is the value of the Chi-square distribution for the given degrees of freedom, 2k+2 and 2k, at the indicated percentiles .90 and .10.

(c) Weibull. The method described in paragraph 3-6.9(4)(b) is used with the exception k is the total number of repair or down times.

D-1.23 O-Level Summary. Following the distributional and related calculations, information is presented for each O-Level having a repair time if the equipment or WRA does not meet repair time requirements. For each O-Level the following is presented:

(1) Identification. The WRA and O-Level Number on the Reliability Block Diagram followed by formal O-Level nomenclature. A 999 indicates failures which could not be assigned to an O-Level. Similarly, a 9 is used if the WRA cannot be identified.

(2) The number of repair times obtained for each O-Level.

(3) The lower and upper 90% confidence limits using equation (20) for each O-Level with more than one repair time. The log-normal distribution was assumed here as the number of repair times expected on each O-Level would be too low to fit a distribution.

(4) The specified MTTR.

(5) The mean of the observed repair times with the low and high observed values.

(6) Whether a maintainability problem exists or not for the given O-Level. A problem exists if the lower confidence limits is greater than the specified MTTR.

D-1.24 2K Summary for Problem Areas. For those components for which a maintainability problem was indicated, summary of each 2K form identified by its JCN is presented following the O-Level calculations described above.

D-1.25 RMA SUMMARY. The automated data analyses summary output first gives the distributions assumed for system reliability and maintainability with estimated parameters. Then, the following availabilities are given.

D-1.26 System Inherent Availability. Inherent availability is defined as the average time a system is available assuming the only system down time is repair time and is given by the following equation:

$$A_I = MTBF/(MTBF + MTTR) \tag{22}$$

The inherent availabilities given are thus obtained by substituting the previously obtained system's MTBF's and MTTR's into the above equation.

D-1.27 System Observed Availability. Observed availability is defined as the ratio of Time To Failure (TTF) to sum of the TTF and Down Time (DT) for each maintenance action and can be expressed as follows:

$$A_{oi} = TTF_i / (TTF_i + DT_i) \tag{23}$$

The mean, median, and confidence limits for A_{oi} are obtained using simulation methods. The distribution and estimated parameters determined in the reliability and maintainability analyses are used to generate the TTF's and DT's. The formulae used to generate these values are as follows:

(1) Exponential

$$TTF_i \text{ or } DT_i = -\theta \ln (1-R_{U_i}) \tag{24}$$

where $\hat{\theta}$ is the estimated MTBF or Mean Down Time (MDT) and R_{U_i} is a random variable from a uniform distribution over the interval (0,1).

(2) Log-normal

$$TTF_i \text{ or } DT_i = \exp (\hat{\sigma} R_{n_i} + \hat{\mu}) \tag{25}$$

where $\hat{\mu}$ and $\hat{\sigma}$ are those values obtained using equations (15) and (16), respectively, and R_{n_i} is a random value from the normal distribution with $\mu = 0$ and $\sigma = 1$.

(3) Weibull

$$TTF_i \text{ or } DT_i = (-\ln(1-R_U)/\alpha)^{1/\beta} \tag{26}$$

where α and β are those values obtained using equations (7) and (8).

As a TTF_i and a DT_i is generated, an A_{oi} is calculated. The mean given is the mean of the 2000 generated A_{oi}'s. The median is the average of the values for which 999 of the A_{oi}'s are greater and 999 are less. The 90% lower and upper confidence limits on individuals are the values for which 10% of the A_{oi}'s are less and 10% are greater, respectively.

REFERENCES

1. ARINC Research Corporation (1964), Reliability Engineering, Prentice - Hall, Inc., Englewood Cliffs, New Jersey, pp 144 - 160, 173

2. Bazovsky, Ivor, (1962) Reliability Theory & Practice, pp 78, 238

3. Hastings, N. A. J. and Peacock, J. B. (1975) Statistical Distributions, John Wiley & Sons, New York & Toronto

4. Miller, Irwin and Freund, John E., (1965), Probability and Statistics for Engineers, Prentice Hall, Inc. Englewood Cliffs, New Jersey, pp 373 - 380

5. D'Agastino, Ralph B. and Noether, Gottfried E. (1973), "On the Evaluation of the Kolmogrov Statistic", The American Statician, Vol. 27, No. 2

6. Locks, Mitchell O. (1973), Reliability, Maintainability, and Availability Assessment, Hayden Book Company, Inc., Rochelle Park, New Jersey, pp 67, 91, 165 - 185

7. Han, Gerald J. and Shapiro, Samuel S. (1967) Statistical Models in Engineering, John Wiley & Sons, Inc., New York - London - Sydney

APPENDIX E

CONDENSED FRAP TECH NOTE
ALLOWANCE PARTS LIST OPTIMIZATION:
AN/WSC-3 SATELLITE COMMUNICATIONS SET

ABSTRACT

The complete Tech Note describes a procedural technique for developing ships allowance parts lists (APLs) for electronic equipment. The technique can be used to optimize the APL for mission availability, APL cost; cost effectiveness, minimum number of elements, volume or weight. The technique incorporates a Monte Carlo simulation model, the results of which have been verified by analytic derivation. This condensed Tech Note presents the results of application of the technique to APL development for the AN/WSC-3 Satellite Communications Set.

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APPENDIX F
GLOSSARY OF TERMS

α-Alpha. The probability of rejecting equipment having a mean time between failure equal to θ_0.

APL. Allowance Parts List.

Availability. The probability that an equipment will be ready for use when its use is required.

β-Beta. The probability of accepting equipment that has a mean time between failure equal to θ_1.

CASRPT. Casualty report.

Censored Data. Data from which subsets of the complete data are removed or are not available.

Censored Times. Equipment operating time not terminated by an operational failure.

Confidence Interval. An interval that has the designated chance (for example, 80%) of including the population parameter (actual population value).

Confidence Limits. The end points of the confidence interval with the designated chance (for example, 90%) that the population parameter will be above (lower limit) or below (upper limit) the stated point.

COSAL. Coordinated Shipboard Allowance.

D-Level. Depot Level.

DRF. Depot Repair Facility.

DT-Down Time. Time equipment was not fully operational.

Equipment Reliability. The probability that an equipment will work as required for a stated time without a failure attributable to the equipment.

ERT-Equipment Repair Time. The median of repair times.

ETM. Elapsed Time Meter.

Failure. Equipment down or in a limited operational status.

I-Level. Intermediate Level.

IMA. Intermediate Maintenance Action.

Inherent Availability. The probability that an equipment will be ready for use when required considering only delays due to on-board repair.

LRI or LRU-Line Replaceable Item or Unit. Part replaceable at the organizational level.

Maintainability (Down Time). The probability that an equipment will be fully operational within a given time after a failure considering all observed delays.

Maintainability (Repair Time). The probability that an equipment will be repaired on-board within a specified time.

Mean. The expected value (center of gravity) of the specified theoretical probability distribution.

Median. The value at which it is estimated that 50% of the population will be below and 50% above.

MDT-Mean Down Time. The mean of down times.

MTBF-Mean Time Between Failures. The mean of time-to-failures.

MTTR-Mean Time to Repair. The mean of repair times.

Nonparametric. No probability distribution is used or assumed.

O-Level. Organizational Level.

Operational (Observed) Availability. The probability that an equipment will be ready for use when required considering all observed delays in repairing equipment.

Operational Failure. Equipment down or in a limited operational status for reasons other than preventive maintenance and approved engineering changes.

Operational Reliability. The probability that an equipment will work as required for a stated time without an operational failure.

Random Variable. A random probabilistic measurable or observable characteristic.

Reliability. The probability that an equipment will work as specified for a given time without failure.

RMA or RAM. Reliability, Maintainability, Availability or Reliability, Availability, and Maintainability.

RT-Repair Time. Time required to repair an equipment on-board a platform.

SATCOM. Satellite Communications.

SEL. Selected Equipment List.

Stochastic Process. A random probabilistic process.

Theoretical Probability Distribution. A previously derived mathematical model which associates probabilities with the equipment characteristic of interest.

θ_0. The mean time between failure desired.

θ_1. The lowest mean time between failure which is acceptable.

TTF-Time To Failure. Time between failures or between initialization and first failure in FRAP time period.

Verification Factor. An estimate of the proportion of operational failures attributable to equipment (the number of confirmed failures plus one-half of the unconfirmed failures divided by the total number of failures).

WRA. Weapons Replaceable Assembly.

ADDENDUM

SHIPS' 3M MANUAL VOLUME II
RECOMMENDED CHANGES TO
INCORPORATE FRAP IN MDS

The changes to OPNAVINST 4790.4, Chapter 9, Maintenance Data Collection Subsystem (MDCS) are listed by paragraph number. When a paragraph was not changed to include FRAP requirements the statement "no change" was made.

9-1 Purpose: No change.

9-2 Objectives.

9-2.1 Maintenance Management to provide the means for:

a. Producing automated Current Ships Maintenance Project reports which categorize and sequence deferred maintenance actions, as required by fleet managers.
b. Producing automated work requests from deferred maintenance actions for submission to activities external to the ship (i.e., tenders, shipyards, ship repair facilities, etc.).
c. Producing automated defiency documents for use by the Board of Inspection and Survey (INSURV).
d. Effective management and control of intermediate maintenance activity (IMA) workloads.
e. Depot level maintenance activities to inform Navy managers of estimated and actual resource expenditures.
f. Producing an automated input into the Ships Force Overhaul Management System (SFOMS) for coordination and management of ships force work during a shipyard overhaul.
g. Gathering information and reproducing automatically, on demand, a history of maintenance information (see chapter 4).

9-2.2 Configuration control to provide the means for the fleet to report configuration changes. Incident to such reporting is the development of the capability to automatically update a ship's Planned Maintenance Subsystem (PMS), Partical Source Data Automation (PSDA), Coordinated Shipboard Allowance List (COSAL), and Ships Equipment Configuration Accounting. A configuration change is:

(a) Any authorized change or modification to installed equipment (Field Change, ORDALT, etc.).
(b) The removal of any installed equipment or system.
(c) The installation of any new or replacement equipment or system.

9-2.3 Reliability Availability and Maintainability Assessment to provide the means for:

a. Fleet units to supply activities responsible for supporting the fleet with historical data for equipment improvement program.

b. Fleet units to supply selected equipment data to the Fleet Reliability Assessment Program (FRAP).

9-3 Description of MDCS. No change.

9-3.1 MDS Reporting. The MDS requires the reporting of equipment related maintenance actions and periodic reporting of failure free operational hours on selected equipment in FRAP. In some instances, MDS requires the reporting of maintenance action related to services, such as, the manufacture of plaques, cruise boxes, etc.

9-3.1 Deferred Maintenance Actions. No change.

9-3.2 Completed Maintenance Action. No change.

9-3.3 Failure Free operational hours reporting:

a. The maintenance man shall report the elapsed time meter (ETM) readings once a month for each selected equipment in FRAP.

b. The maintenance man shall report the final ETM reading on the removal of any installed selected equipment and the initial ETM reading on any new or replaced selected equipment in FRAP.

9-4 MDS Forms. No change.

9-4.1 OPNAV 4790/2K: Ships Maintenance Action Form (Figure 9-1). This form is used by maintenance personnel to report:

a. Deferred maintenance actions.
b. Completed maintenance actions (including those previously deferred).
c. Failure free operating hours reporting - selected equipments in FRAP.

This form also allows the entry of screening and planning information for management and control of IMA workloads.

9-4.2 No change.

9-4.3 No change.

9-4.4 No change.

9-4.5 No change.

9-4.6 No change

9-4.7 No change

9-5 No change.

9-5.1 No change

9-5.1.1 No change.

9-5.1.2 No change

9-5.1.3 No change.

9-5.1.4 Section IV, Remarks/Description. This section must be filled in when reporting the deferral of a maintenance action. With the exception of safety related situations, configuration changes, and FRAP selected equipment, it is filled in when reporting the completion of a maintenance action only when such remarks are considered significant to the maintenance action. It must be filled in to describe situations which are safety related. Also, it must be completed in a prescribed format when reporting configuration changes (see paragraph 9-5.4.1.b(2)). Further, it must

it must be completed for FRAP selected equipment as described in paragraph 9-5.4.2.d(3). This section will also be used to denote failure free hours reporting for FRAP selected equipment.

9-5.1.5 No change.

9-5.1.6 No change.

9-5.2 Documenting a Deferred Maintenance Action. The maintenance man shall report the deferral of that maintenance which (1) requires some type of assistance from an activity external to the ship; (2) is not expected to be accomplished by ships force within 30 days; (3) describes maintenance related deficiencies reported by INSURV (see paragraph 9-5.9). An original and five copies of the OPNAV 4790/2K are required for deferring any maintenance actions. Two additional copies are required for FRAP selected equipments. The original is forwarded to the automatic data processing facility serving the activity. The first copy is submitted when reporting the completion of that maintenance action, the second copy is preferably attached to or if not possible placed in the shipping container with the deferred part or equipment, the third copy is mailed to the FRAP cognizant Data Collection Activity (specified by lead FRAP activity as described in paragraph 9-6) at time of deferral, the fourth copy is mailed to the cognizant FRAP Data Collection activity upon completion of the deferral, and the fifth copy is retained until completion data appears on the CSMP after which it may be destroyed. For FRAP selected equipments, failed throw-away parts shall be tagged with the JCN during which they were discovered and mailed to the cognizant FRAP Data Collection Activity.

The following paragraphs contain detailed instructions, block-by-block, of each section that applies to a deferred maintenance action as originated by a ship or activity.

Check the block at the top of the form titled, "Deff".

9-5.2.1 Section I-Identification. No change.

9-5.2.2 Section II-Deferral Action. Change to:

This section indicates elapsed operating time on equipment and ships force manhours expended up to the time of deferral, ships force manhours remaining, and if the work must be completed by a certain date.

a. Meter Reading. Blank space after words DEFERRAL ACTION. For FRAP selected equipment using the time meter specified by the cognizant FRAP SYSCOM (see paragraph 9-6) record to the nearest whole hour the reading at the time the malfunction was observed and at the time any alteration (SHIPALT, ORDALT, FLD CHG, etc.) was deferred.

9-5.2.2a. Block 25-S/F MHRS Exp (Ships Force Manhours Expended). Change paragraph designation from 9-5.2.2a. to 9-5.2.2b.

9-5.2.3.b. Block 26-Defer Date (Deferral Date). Change paragraph designation from 9-5.2.2.b to 9-5.2.2c.

9-5.2.2.c. Block 27-S/F MHRS REM (Ships Force Manhours Remaining). Change paragraph designation from 9-5.2.2c to 9-5.2.2.d.

9-5.2.2.d. Block 28-DEADLINE DATE. Change paragraph designation from 9-5.2.2.d to 9-5.2.2.e.

9-5.2.3 Section IV-REMARKS/DESCRIPTION. No change.

9-5.2.3.a. REMARKS/DESCRIPTION. Add: (4) For FRAP selected equipment, identify parts deferred with their number and a short description such as name, specify diagnostic indicating failure, give any unique symptoms at time of or prior to malfunction, and temperature and humidity at time malfunction observed. If required, this additional information may be put on another OPNAV 4790/2K or a OPNAV 4790/2L form having the same JCN as the first form. However, copies of all the forms are to be mailed to the FRAP cognizant Data Collection Activity.

9-5.2.3.b. No change

9-5.2.3.c. No change.

9-5.2.3.d. No change.

9-5.2.3.e. No change.

9-5.2.3.f. No change.

9-5.2.3.g. No change.

9-5.2.3.h. No change.

9-5.2.3.i. No change.

9-5.2.3.j. No change.

9-5.2.3.k. No change.

9-5.2.3.l. No change.

9-5.2.4 SECTION V-SUPPLEMENTARY INFORMATION. No change.

9-5.3 Deferred Maintenance Action Screening. No change.

9-5.3.1 Section IV-Screening Entries. No change.

9-5.3.2 Section E-Supplementary Information. No change.

9-5.3.3 Section VI-Repair Activity Planning/Action. No change

9-5.4 Completed Maintenance Action. No change.

9-5.4.1 Completion of Previously Deferred Maintenance. The maintenance man shall report completion of previously deferred maintenance actions by using the copies of the OPNAV 4790/2K retained on board when the maintenance action was deferred. The

The OPNAV 4790/2K or OPNAV 4790/2R may also be used if produced by the supporting ADP facility. With the exception of FRAP selected equipments, there may be times when there is no record copy of the OPNAV 4790/2K, 4790/2R or 4790/2Q available on board but maintenance action is listed in the CSMP. In this case, put the JCN on a blank OPNAV 4790/2K and use to complete the previously deferred maintenance action in place of the lost document.

If the TYCOM allows "Automatic Close Out" and "AUTO" has been entered in Block 27 on the deferral, submission of a completed maintenance action by the originating ship will be necessary only for FRAP selected equipments.

Upon completion of the deferred action, the FRAP copy will be mailed to the cognizant FRAP Data Collection Activity (specified by the lead FRAP activity as described in paragraph 9-6).

When the FRAP copy has been mailed and the completion of the maintenance action is reflected on the CSMP, all suspence copies of the deferral may be discarded.

The procedures for reporting completion of previously deferred maintenance are as follows:

9-5.4.1.a. Section III - Completed Action. As is with the exception of first paragraph of (6) which should read as follows:

(6) Block 34-METER READING. Using the time meter specified by the cognizant SYSCOM record to the nearest whole hour the reading of the meter AT THE TIME THE MALFUNCTION WAS REPAIRED OR AN ALTERATION COMPLETED.

9-5.4.1.b. Section IV-Block 35-Remarks/Description. Change paragraphs (1) and (2) as follows:

(1) When the "What must be done" statement on the original deferral accurately describes the work which was accomplished, denote in parenthesis "Work Accomplished".

(2) If additional remarks are needed to describe the work done, draw a line through all previous remarks and starting on the next line:

(a) Describe what was done.
(b) Provide any additional information considered significant which was not included in the description on the original deferral. For FRAP selected equipments, include identification of parts replaced by their number and a short description such as name and also give other actions such as alignment, recalibration required to complete maintenance actions.

An example of this type entry would be:

As is. No change.

9-5.4.1.c. Section VI-Repair Activity Planning/Action. No change.

9-5.4.2 Completion Without Prior Deferral. Change b to:

b. Report corrective maintenance on non-FRAP selected equipments as defined in paragraph 9-6.

Add following after d(3):

For FRAP selected equipments the original and a copy of the OPNAV 4790/2K form will be prepared and submitted for all maintenance actions without prior deferral.

The original OPNAV 4790/2K is always forwarded to the automatic data processing facility serving the activity. For FRAP selected equipment, the second copy will be mailed to the cognizant FRAP Data Collection Activity (specified by the lead FRAP activity as described in paragraph 9-6). Additional, for FRAP selected equipment, failed throw-away items shall be tagged with the JCN of the maintenance action during which they were discovered and mailed to the cognizant FRAP Data Collection Activity.

Eliminate present sentence: "The OPNAV 4790/2K is forwarded to the automatic data processing facility serving the activity".

9-5.4.2.a. Section I-Identification. No change.

9-5.4.2.b. Section III-Completed Action. No change.

9-5.4.2.c. Selected Equipments Only. Change first paragraph of (3) to:

(3) Block 34-Meter Reading. Using the time meter specified by the cognizant SYSCOM record to the nearest whole hour the reading of the meter AT THE TIME PROBLEM WAS DISCOVERED or alteration (SHIPALT, ORDALT, FLD CHG, etc.).

9-5.4.2.d. Section IV-Remarks/Description. Add the following:

(3) For FRAP selected equipments, state what is wrong, specify the diagnostic indicating the problem, list any unique symptoms prior to or at time problem is discovered, and give temperature and humidity at time problem discovered. Then, give what was done to correct the problem identifying any parts replaced by their number and a short description such as name. Also, specify other actions such as alignment, recalibration required to complete the maintenance actions for FRAP selected equipments.

9-5.4.2.e. Section VI-Repair Activity Planning/Action. No change.

9-5.5 Documenting Changes, Additions and Deletions to MDS. Change to 9-5.6 and insert following for 9-5.5.

9-5.5 Failure Free Time Reporting

Maintenance personnel shall use the OPNAV 4790/2K form to report failure free operating time required for FRAP selected equipments which is defined in paragraph 9-6. This requires completing only limited portions of the IDENTIFICATION, COMPLETED ACTION, and REMARKS/DESCRIPTION Sections (I, II, and IV, respectively). These forms will be submitted at the end of each month; and upon the removal of any FRAP selected equipment, and upon the installation or replacement of any FRAP selected equipment.

An original and one copy of the OPNAV 4790/2K are required for failure free reporting. The original is forwarded to the atuomatic data processing facility serving the activity. The copy is mailed to the FRAP cognizant Data Collection Activity (specified by the lead FRAP activity as described in paragraph 9-6).

The following paragraphs contain instruction for the blocks of each section that apply to failure free reporting.

Do not check the deferral or completion boxes at top of the form.

9-5.5.1 Section I-Identification. The entries in this section will identify the equipment or system for which failure free operating time is being reported.

a. Block A-Ship's Name. Insert the name of the activity originating the form. For example: "USS JOHN KING".

b. Block B-Hull Number. Insert the type and hull number of the ship originating the form. For example: "DDG-3". Activities other than ships will leave Block B blank.

c. Job Control Number (JCN). As the JCN is the key identification for maintenance actions and their related supply documents, only the unit identification code (UIC) and work center portion of the JCN will be used for failure free time reporting thus distinguishing it from the corrective maintenance actions.

(1) Block 1-Ships UIC. Enter the UIC of the activity originating the form. NAVCOMPT Manual, Volume 2, Chapter 5, contains a listing of UIC's. When the listed UIC contains only four digits, a zero is entered as the first position. For example: "04669" (Note: For service craft, use the UIC of parent activity).

(2) Block 2-Work Center. There are four basic types of work center codes. This application and definition are as follows:

(a) Ships-Ships use a four position work center code. The first two positions identify the department and division. The last two positions identify the work center within the division.

(b) Repair departments of tenders and other IMA's-These organizations use a three position work center code to identify the repair shops (e.g.: 10A, 67A, 91A, etc.). The three position work center code is recorded from left to right, leaving the right most position blank.

(c) Fleet Maintenance Assistance Groups-These groups use the three position work center code assigned to the repair shop with which they are associated, but shall insert an "F" in the right most position (e.g.: 67AF, 91BF, etc.).

(d) Service Craft-Service craft personnel shall use the four position code assigned by the parent activity to identify the individual service craft. The first two positions shall be alpha and the second two positions shall be numeric.

(3) Block 3-Job Seq. No. Number used for failure free time reporting.

d. Block 4-APL/AEL (Allowance Parts List/Allowance Equipment List). Not required for failure free time reporting.

e. Block 5-Equipment Noun Name. Enter the noun name of the equipment on which failure free is being reported. The noun name is limited to 16 positions; use standard abbreviations, if necessary, while retaining clarity. For those electronic equipments having an AN (Army=Navy) desgination, it will be substituted for the noun name of the equipment.

f. Block 6-WND (When Discovered). Not used in failure free time reporting.

g. Block 7-STA (Status). Not used in failure free time reporting.

h. Block 8-CAS (Casue). Not used in failure free time reporting.

i. Block 9-DFR (Deferral Reason). Not used in failure free time reporting.

j. Block 10-Blank. Not used.

k. Block 11-Blank. Not used.

l. Block 12-Blank. Not used.

m. Block 13-Ident/Equipment Serial Number. Enter the identification or serial number of the equipment or system on which failure free time is being reported.

(1) For electronics and ordnance equipment, enter the serial number from the nameplate of the equipment. Example: For AN/SPS-10C radar with serial number 48, the number"48" would be entered.

(2) For hull, mechanical and electrical equipment, enter the ship's numbering system. Example: For number 1A boiler, the number "1A" would be entered.

(3) On items such as phones, fans, etc., more than one item may be listed on the same OPNAV 4790/2K as long as all other data in section I is the same. In these cases, enter "VARIOUS" in the block.

(4) Enter the abbreviation "NA" (Not Applicable) where no specific identification or equipment serial number is given.

(5) If the serial number exceeds 12 characters, leave the block blank and enter the words "Serial Number" in the narrative, followed by the applicable number.

n. Block 14-EIC (Equipment Identification Code). In the first four positions of this block enter the EIC of the equipment or system for which the time is being reported. The EIC is a four character code-the first position identifies the system; the second identifies the subsystem; and the last two identify the equipment in that subsystem. Applicable EICs are listed in the EIC Master Index (MSO 4790.E25 79). An example of the entry for boiler number 1A is "F101".

In the event that an equipment is not specifically listed in the EIC Master Index, but can be identified to the subsystem, enter the subsystem identification, followed by two zeros. For example: An equipment is identified as "TRANSCEIVERS-COMMUNICATIONS", but is not listed in the EIC Master Index, enter "QD00".

In the rare event the equipment may be identified only to the system, enter the system identification, followed by three zeros. For example: An item of test equipment is identified as "ELECTRONIC TEST EQUIPMENT", enter "WOOO".

o. Block 15-Safety Hazard. Not applicable to failure free time reporting.

p. Block 16-Location. Enter the location of the equipment or system on which the reading is being reported. It is made up of four elements separated by dashes(-).

(1) COMPARTMENT. The "Compartment" entry should be the compartment number. In those cases where a compartment number is not designated; i.e. equipments installed on weather decks, the noun name of the deck should be used. For example: "FANTAIL", "FLIGHT DECK", etc.

(2) DECK. The "deck" entry should identify the deck level on which the equipment or system is located; i.e., 2, 1, 01, 02, etc.

(3) FRAME. The "frame" entry identifies the frame within the ship where or near where the equipment or system is located.

(4) SIDE. The "side" entry identifies the side of the ship or compartment where the equipment or system is located. "1" = Starboard, "2" = Port and "0" = Center Line. Note: Submarines shall report location by compartment, or compartment and deck level only, e.g., "TORP RM" (Torpedo Room); "OPS-UL" (Operations Compartment Upper Level); "ENG RM-LL" (Engine Room Lower Level).

q. Block 17-When Discovered Date. Not used for failure free time reporting.

r. Block 18-Alterations (SHIPALT, ORDATL, FLD, CHG, etc.). Not required for failure free time reporting.

s. Blocks 19 through 24-INSURV Designation. Not used for failure free time reporting.

9-5.5.2 Section III-Completed Action. This section is used to present the date of the meter reading and the actual meter reading.

a. Block 29-ACT TKN (Action Taken). Not used in failure free time reporting.

b. Block 30-S/F MHRS (Ships Force Manhours). Not used in failure free time reporting.

c. Block 31-Completion Date. Enter the Julian date the time meter was read. For example, if the time meter was read on 30 Jan 1977, enter "7030".

d. Block 32-ACT Maintime (Active Maintenance Time). Not used in failure free time reporting.

e. Block 33-TI-Trouble Isolation. Not used in failure free reporting.

f. Block 34-Meter Reading. Using the time meter specified by the lead FRAP SYSCOM (NAVELEX) record to the nearest whole hour the reading on FRAP selected equipment:

(1) At the end of each month.

(2) When removed and not reported or a previous OPNAV 4790/2K.

(3) When installed (includes replacement) and not reported on a previous OPNAV 4790/2K.

9-5.5.3 Section IV-Remarks/Description. This section contains a short description of the type of failure free hour reporting.

a. Block 35-Remarks/Description. Specify whether the failure free reportin time reporting is for monthly reporting, removal of equipment, or installation (replacement) of equipment.

9-5.5 Documenting Changes, Additions, and Deletions to MDS. Change paragraph designation from 9-5.5 to 9-5.6 and change as follows:

Any block (including the narrative but excluding the Job Control Number) on an OPNAV 4790/2K reporting on maintenance action can be added, deleted, or changed after it has been entered into the 3-M and FRAP computer programs. Maintenance personnel will use a original and for FRAP selected equipment one copy of the OPNAV 4790/2K to enter modifications. The following procedures are mandatory to ensure the modification is entered into the system correctly.

a. Print "CORRECTION" at top of the form.

b. Blocks 1, 2, and 3-JOB CONTROL NUMBER (JCN). Enter the JCN of the original OPNAV 4790/2K submitted previously for the maintenance action.

c. Block 31-Completion Date. Enter the Julian date of the day the modification is being submitted. The date must be later than that of the original 4790/2K form being modified.

d. Enter only the information to be added, deleted or changed in the applicable blocks of the form. Encircle these blocks. In situations where information is to be deleted, enter the data to be deleted and draw a line through it.

CAUTION

When changing Block 35-REMARKS/DESCRIPTION. The entire revised narrative must be entered so that correct information and change information is included. It is not possible to change just a word or two in the REMARKS/DESCRIPTION without resubmitting the entire narrative.

The OPNAV 4790/2K containing the change information is forwarded to the supporting ADP facility maintaining the ship's CSMP and for FRAP selected equipment the copy is mailed to FRAP cognizant Data Collection activity specified by the lead FRAP SYSCOM (see paragraph 9-6).

Figure 9-19 is an illustration of a change submitted to reflect a change in type availability code and priority code.

See paragraph 9-5.8.2 for entry of INSURV information.

9-5.6 OPNAV 4790/2Q. Change present paragraph designation 9-5.6 to 9-5.7.

9-5.7, 9-5.7.1, 9-5.7.2, 9-5.7.3. Change these present designations to 9-5.8, 9-5.8.1, 9-5.8.2, and 9-5.8.3, respectively.

9-5.8, 9-5.8.1, 9-5.8.2, 9-5.8.2.1, 9-5.8.3. Change these present designations to 9-5.9, 9-5.9.1, 9-5.9.2, 9-5.9.2.1, and 9-5.9.3, respectively.

9-6. SELECTED EQUIPMENTS.

9-6.1 SELECTED EQUIPMENT DEFINITION. The equipments designated as selected equipments in the context of the 3-M MDS are equipments or systems, in the fleet, which have suspect Reliability, Availability or Maintainability (RAM) indicies. The equipments or systems either have a proven history of unreliability, or are new, or modified installations for which the RAM indicies have not been established.

9-6.2 SELECTED EQUIPMENT PROGRAMS.

a. There will always be certain equipments or systems in the fleet which have a history of unreliability. Such items are designated as "selected equipment". The Chief of Naval Material (CNM), assisted by TYCOMS and SYSCOMS, has the responsibility for establishing and maintaining the selected equipment list (SEL) contained in OPNAVINST 4790.6. MSOD is responsible for providing each ship with a tailored SEL containing equipments for which the ship is required to report under this program.

b. Equipments or systems which have either suspect RAM indicies or are new, or modified installations for which RAM indicies have not been established shall be reported as selected equipment under the Fleet Reliability Assessment Program (FRAP). The Chief of Naval Operations (CNO), via CNM has established the Naval Electronics System Command (NAVELEXSYSCOM) as the lead SYSCOM with the responsibility for establishing and maintaining FRAP. NAVELEXSYSCOM is responsible for promulgating to the Fleet equipment to be placed under FRAP and with the assistance of the TYCOMs is responsible for designating ships and submarines which will report the FRAP data. The FRAP data will be reported to the cognizant Data Collection activity specified by NAVELEXSYSCOM. Information concerning FRAP can be obtained from NAVELEXSYSCOM (ELEX-04).

9-7. No change.

9-8. No change.

9-9. No change.

9-10. No change.

9-11. No change.

List of Acronyms. Add FRAP - Fleet Reliability Assessment Program.